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# Simulation Research on Back Flushing Time of High Pressure Back Flushing Filter Station

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**Abstract.** The hydraulic support system in fully mechanized face is huge and complex, working environment is special, so emulsified pollution is an outstanding problem, which influences the performance and efficiency of the hydraulic support system, high pressure back flushing filter station is an important emulsion cleaning equipment in the system. The pollution control model is constructed, pollution equilibrium equations are derived for high pressure emulsion back flushing filter station in ore. Flow division coefficient and back flushing efficiency are introduced for back flushing time simulation research, that indicate the parameters influence relation for back flushing time, at last accuracy and feasibility of the pollution control simulation model is discussed by the comparison analysis of experimental and simulation results, the higher the back flushing efficiency is, the higher the flow division coefficient is, the shorter the back flushing time is, and the higher the cost is, the back flushing model based on pollution control is effective that provides a theoretical criterion for the optimal design of high pressure back flushing filter station.

**Keywords.** Back Flushing, Pollution Control Model, Pollution Equilibrium Equation, Back Flushing Time, Simulation.

## 1. Introduction

High pressure back flushing filter station is an important emulsion cleaning equipment in the hydraulic support system, and its quality affects greatly the hydraulic support system. Current researches of emulsion back flushing filter station mainly concentrate on function design and control [1-3], but few researches are on the performance of back flushing time, back flushing efficiency and so on. Filter material such as quartz sand media and walnut shell are used in other fields [4-6], the back flushing filter mathematical model is established, and the theoretical back flushing time is calculated, which has some references to the design of high pressure back flushing filter station. A back flushing filter pollution control mathematical model is established in simplified [7], which doesn't reflect the influence of each parameter. According to the emulsion back

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flushing filter station principle in ore and pollution control model equilibrium theory [8], the pollution control model and AMESim simulation model are constructed for high pressure emulsion back flushing filter station, the parameters influence relation for back flushing efficiency parameters and flow are investigated in this paper.

## 2. High Pressure Back Flushing Filter Station

The emulsion back flushing filter station principle in ore was shown in figure 1. There were two electromagnetic pilot valves, two hydraulically controlled main valves and two high pressure filters with filtering precision 25 μm in the station [9]. The filter core cleaning was controlled by electromagnetic pilot valves opened and closed, at the same time we set the modes fixed time interval control, differential pressure-time interval control and so on.

## 3. Pollution Control Model in Back Flushing Filter Process

Inlet-outlet differential pressure of the filter core increased monotonically with the continuous filter, when the differential pressure reached the setting value, the filter station entered the back flushing filter process. The oil flow rate used in the process was only a part of total flow, $\alpha_F$ the flow proportional coefficient in back flushing process to the total flow, $\eta$ back flushing efficiency, represented the ratio of back flushing pollution particle counts washed away to total deposition pollution particle counts. The pollution control model was constructed in the research of the back flushing pollution control process as shown in figure 2.

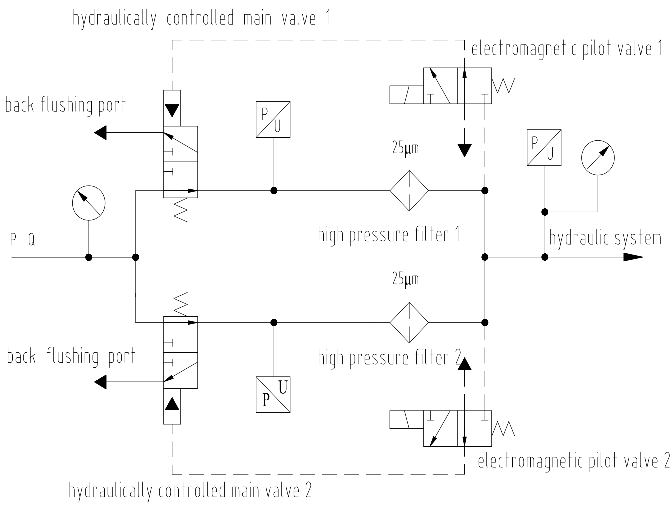


**Figure 1.** Principle of high pressure back flushing filter station

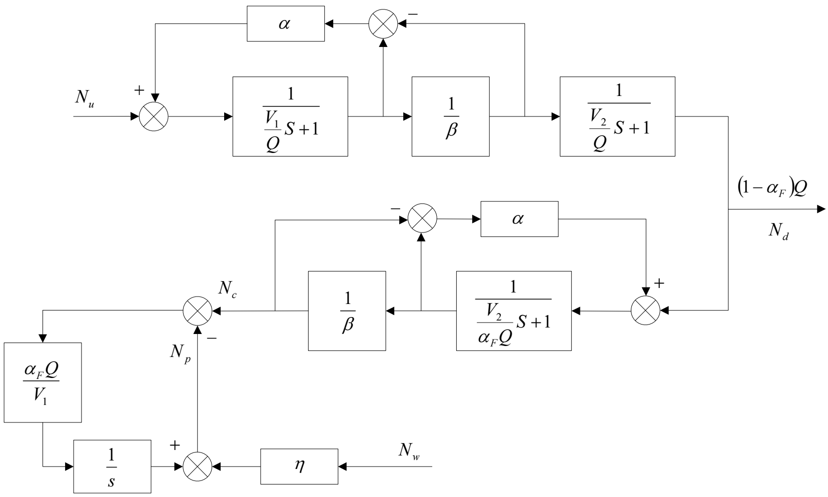


**Figure 2.** Back flushing pollution control model

According to the pollution particle counts conservation, back flushing cavity pollution equilibrium equation is as follows

$$N_p V_1 = N_w V_1 + \int \left(N_c - N_p\right) \alpha_F Q dt \tag{1}$$

Divided $V_1$ both sides

$$N_p = N_w + \frac{\alpha_F Q}{V_1} \int (N_c - N_p) dt \tag{2}$$

In the above equation: $Q$—the total flow in filter station, $\mathrm{L/min}$. $N_c$—pollution concentration in back flushing process, $\mathrm{ind/mL}$. $N_w$—initial concentration in pollution cavity, $\mathrm{ind/mL}$. $V_1$, $V_2$—the inlet-outlet cavities of the filter core, mL. $N_p$—pollution concentration at sewage outlet, $\mathrm{ind/mL}$. $\alpha_F$—the flow proportional coefficient in back flushing process to the total flow.

## 4. Simulation Research on Back Flushing Process

### *4.1. AMESim Simulation Model*

According to the hydraulic pollution control model, AMESim simulation model on back flushing filter station was constructed in figure 3.

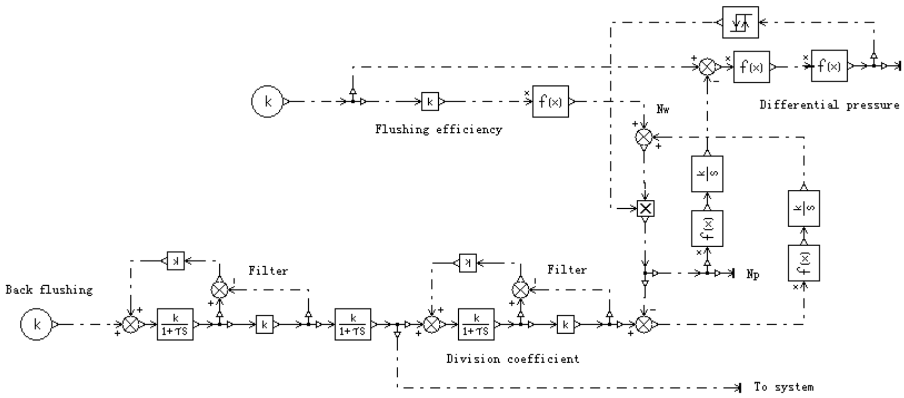


**Figure 3.** Back flushing simulation model

Repetition filter factors, back flushing efficiency and flow division coefficient were introduced in back flushing simulation model, which calculated real-time deposition pollution particle counts in filter front cavity and corresponding differential pressure, all the parameters needed were in table 1.

**Table 1.** Parameters

| Parameter | Value |
|---|---|
| Filter cavity inlet | 1 L |
| Filter cavity outlet | 1 L |
| Filter ratio in filter core | 100 |
| Flow through filter station | 400 L/min |
| Initial differential pressure in filter core | 0.15 MPa |
| Back flushing stopped differential pressure | 0.2 MPa |
| Ultimate differential pressure in filter core | 0.8 MPa |
| Quantity of pollutants received | 769.3 g |
| Repetition filter factors | 0～0.95 |
| Back flushing flow division coefficient | 0.06～0.25 |
| Back flushing efficiency | 0.6～1 |

### *4.2. Back Flushing Filter Simulation*

Back flushing filter began after forward flushing filter when the differential pressure pre and post reached the back flushing setting value, the pollution concentration in back flushing cavity was obtained from the forward flushing filter simulation. According to the results of the forward flushing filter simulation, when the differential pressure pre and post reached the back flushing setting value 0.8MPa, deposition pollution particle counts in filter front cavity were $1.01855\times10^{10}$ ind, all particles were dissolved to filter cavity volume that was initial concentration in pollution cavity.

Simulation according to the above settings, the curves in figure 4 show the influence of back flushing efficiency $\eta$ and results, the simulation results show that the higher the back flushing efficiency is, the shorter the back flushing time is, when $\eta$ is 1, back flushing time just is 4.638 s, and when $\eta$ is 0.94, back flushing time needed is 7.278 s. However, when $\eta$ is less than 0.94, the differential pressure pre and post of the filter cannot be reduced to the required 0.2 MPa. Therefore, the higher back flushing efficiency is, the better the back flushing effect is, the shorter the back flushing time is also, the design of the back flushing filter station can apply the ultrasonic device by using ultrasound of the high frequency vibration of thousands of times per second, the function of ultrasonic cavitations will separate pollution particle counts on filter core, effectively improve the back flushing efficiency and back flushing effect in the filter.

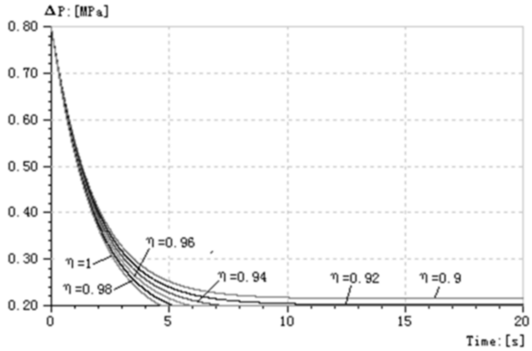


**Figure 4.** Effect of back flushing efficiency and results

Figure 5 shows the relation curves between the flow division coefficient $\alpha_F$ and the back flushing effect. The flow division coefficient is in four specifications analyzed according to the sizes of the common hose and the main hypertension line 0.06, 0.1, 0.16 and 0.25. According to the simulation results, the higher the flow division coefficient is, the shorter the back flushing time is. When $\alpha_F$ is 0.25, the back flushing time is only 1.615s, while when $\eta$ is 0.06, the back flushing time is 6.746s. However, the higher the flow division coefficient is, the more flow is used for the back flushing, the higher the cost is. Therefore, it is necessary to reasonably design the flow division coefficient and the back flushing time, and tradeoff cost while considering the back flushing time.

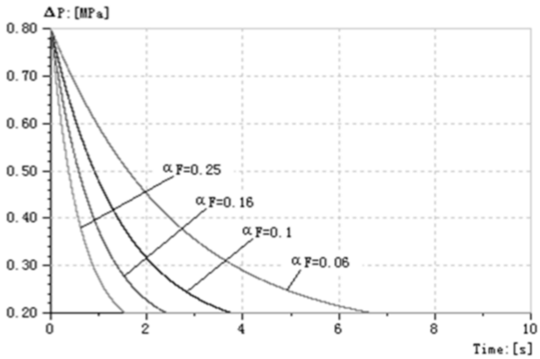


**Figure 5.** Effect of division coefficient and back flushing results

## 5. Comparison between Experimental and Simulation

Filter parameters provided by the manufacture, setting the ultimate differential pressure on the filter core is 0.8 MPa, and considering the initial differential pressure in filter cylinder is 0.6 MPa and the initial differential pressure on the filter core is 0.2 MPa, so setting the ultimate differential pressure of filter station is 1.6 MPa. Figure 6 shows back flushing directly and ultrasonic back flushing test curves, the experimental results show that back flushing starts when the differential pressure reaches 1.6 MPa, differential pressure decreases rapidly, differential pressure doesn't change after 6.5 s, differential pressure is basically kept at 0.94 MPa. However, the starting of the ultrasonic back flushing in the test, the differential pressure decreases rapidly, and the differential pressure doesn't change after 6 s, differential pressure is basically kept at 0.83 MPa.

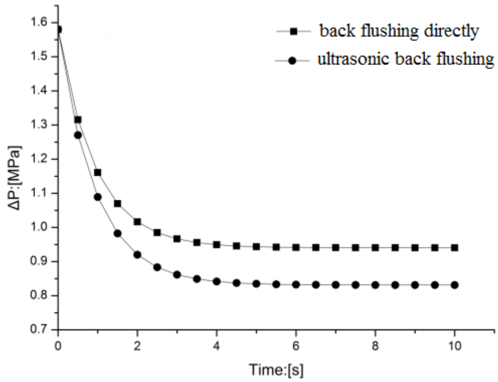


**Figure 6.** Experimental curves of back flushing directly and ultrasonic back flushing

Back flushing simulation curves are in figure 7 , different back flushing efficiency corresponding different filter core differential pressure, which obtain by back flushing simulation model calculated and the actual parameters of filter station. The simulation shows when the back flushing efficiency $\eta$ is 0.8, stability differential pressure is 0.956 MPa after 6.2 s, when $\eta$ is 0.85, stability differential pressure is 0.917 MPa after 6 s, when $\eta$ is 0.9, stability differential pressure is 0.878 MPa after 5.8s, when $\eta$ is 0.95, stability differential pressure is 0.839 MPa after 5.7 s, and when the back flushing efficiency $\eta$ is ideal 1 , stability differential pressure is 8 MPa .

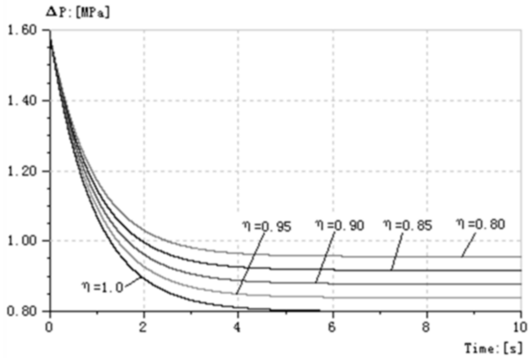


**Figure 7.** Back flushing simulation curves

From experimental and simulation comparison, the back flushing simulation curves and the differential pressure curve measured by experimental are similar, the experimental and simulation of the back flushing time are also close, that verify the effective of the back flushing model based on pollution control in this paper, that provide a necessary theoretical criterion for high pressure back flushing filter station optimal design. In addition, by contrast, the back flushing directly efficiency can be between 0.8 ~ 0.85, and ultrasonic back flushing efficiency is between 0.95~1, ultrasonic wave can improve the back flushing efficiency greatly, reduce the filter differential pressure inlet and outlet, reduce the pressure loss of hydraulic system and improve the system efficiency.

## 6. Conclusions

From above the back flushing pollution control model simulation, the results are as follows:

1) The higher the back flushing efficiency is, the shorter the back flushing time is. Ultrasonic wave or vibration can be adopted to improve the back flushing efficiency.

2) The higher the flow division coefficient is, the shorter the back flushing time is, and the more the flow is used for the back flushing, the higher the cost is. Therefore, reasonable selection and design of the flow division coefficient and back flushing time are necessary.

3) The back flushing model based on pollution control is effective that provides necessary theoretical criterion for the optimization design of the back flushing filter station.

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